Wideband Microstrip Patch Antenna at 7 GHz

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Abstract: : In this study, an edge-fed microstrip patch antenna at 7.1 GHz is designed and simulated. Simulated results are presented by using Sonnet software [1], a planar 3D electromagnetic simulator. Among those results, the real part of the input impedance is almost 50 ohms, phi-polarized electric field radiation pattern gain is 4.5 dB, cross-polarization level is under –20 dB, and the –10 dB return loss bandwidth is almost 10%.

Keywords: Microstrip, Patch, Antenna, Bandwidth, Wideband

1. Introduction

There are some works in the literature about the antennas around 7 GHz. One of them uses impedance matching method in order to increase the bandwidth at different frequencies. They applied this method to their design, and achieved 20%-bandwidth stacked patch antenna at 7GHz [2]. Bandwidth increasing is one of the design challenges in the design of microstrip patch antennas. Several techniques are formulized for different input geometries [3]. This work uses some similar and other different approaches as explained step by step in the next section.

2. Design procedure

Figure 1 has the top view and Figure 2 has the 3D view of the antenna. The antenna dimensions are 30.15 mm x 43.48 mm. Dielectric thickness is 2.54 mm., and dielectric constant is 3.9 for FR–4. The work started with very low gain. Even though the return loss of under –20 db levels are achieved, the gain was still low. This situation caused to make changes on the geometry. Those changes are explained in three steps below, and the affects of the changes in the design parameters are mentioned in Table 1.

1. There was no gain without the indentation located at the top-center, and the bottom horizontal metal radiator located at the input of the antenna.
2. First, the top-center indentation is added and there was an increase on both the gain and the return loss.
3. Second, the bottom horizontal metal radiator located at the input of the antenna is added and the final results are achieved.

Table 1:Parameter value changes with design steps

Parameters	1. step	2. step	3. step
Resonance frequency	7.1 GHz	7.1 GHz	7.03 GHz
S11	-15.74 dB	-21.3878 dB	-17.02 dB
Bandwidth (freq.) Bandwidth (%)	400 MHz 5.63 %	600 MHz 8.45 %	550 MHz 9.23 %
Gain	1.337 dB	3.37 dB	3.76 dB

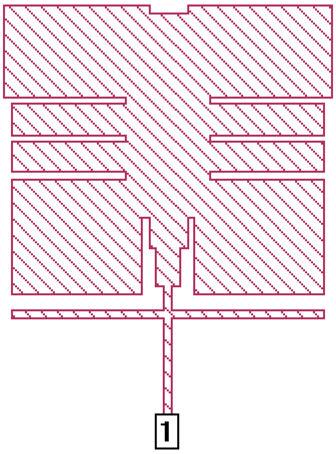

Fig. 1. Top view of the antenna.

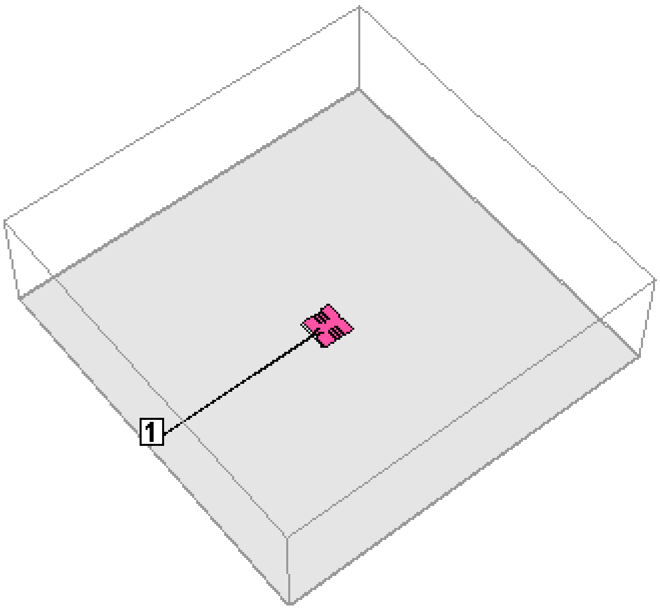

Fig. 2. 3D view of the antenna.

3. Simulation Results

Figure 3 has the return loss of the antenna at 7.03 GHz, when air layer thickness is 20 mm.

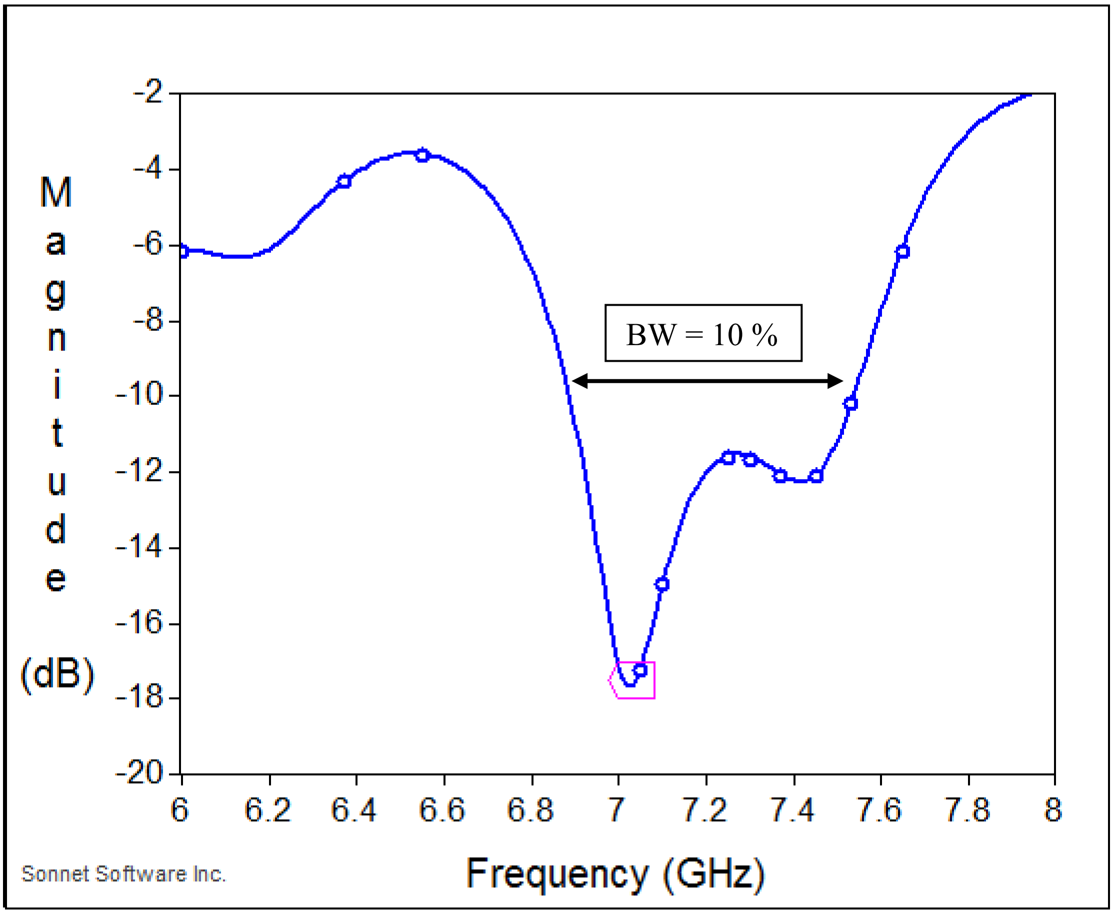

Fig. 3. Return loss of the patch antenna.

The real part of the input impedance is 65 Ω, and the imaginary part of the input impedance is 3.16 Ω. When we make the air layer thickness 100 mm. for the step 3, maximum gain of 4.49 dB is maintained with a fraction of a frequency shift, but the bandwidth is decreased. This pattern is seen on Figure 4. The real part of the input impedance is 50.3 Ω, and the imaginary part of the input impedance is 7.33 Ω. Those changes are explained in Table 2.

Table 2:Parameter value changes with air layer thickness of 100 mm

Resonance frequency	7.03 GHz	7.1 GHz
S11	-22.82 dB	-17.02 dB
Bandwidth (%)	2.27 %	5.23 %
Gain	3.03 dB	4.49 dB

The phi-polarized electric field radiation pattern is illustrated on Figure 4. As it is seen on the figure that, the cross-pol. level (E-theta) is –20 dB, and the pattern is symmetric.

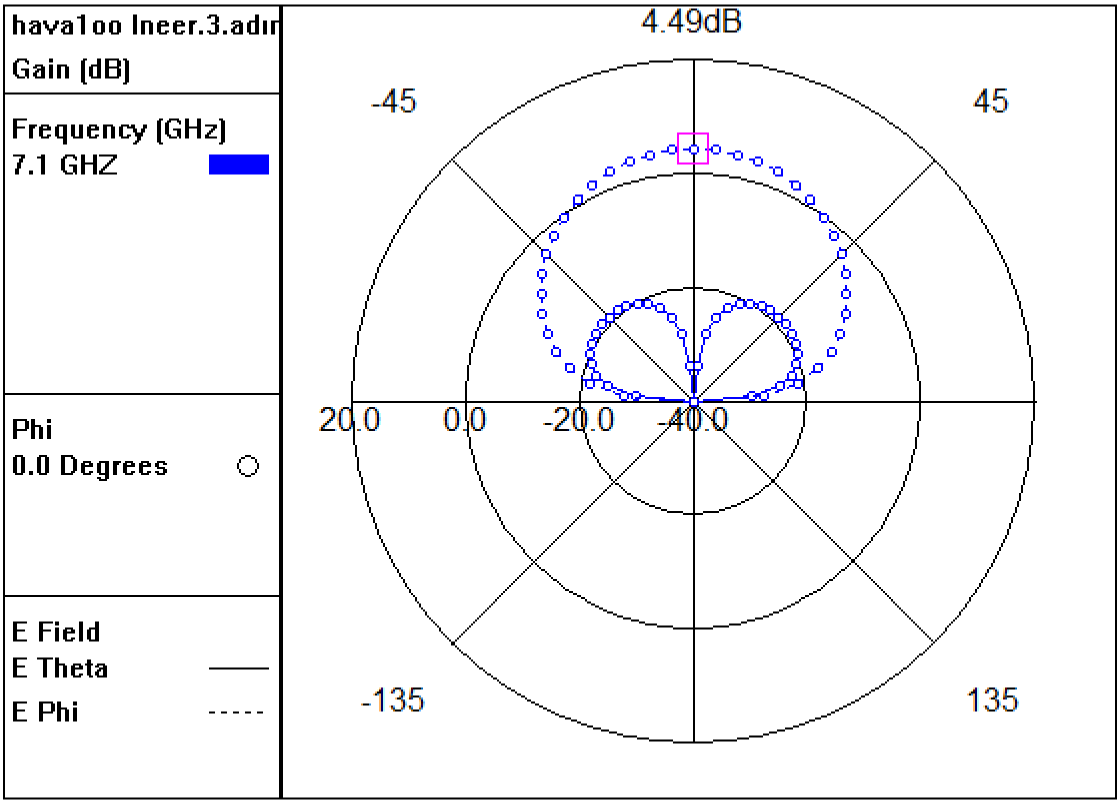

Fig. 4. Far field radiation pattern of the antenna at 7.1 GHz.

The current on the antenna can be seen on Figure 5. As the affect on the gain is explained in section 2, the current is very crowded at the bottom horizontal metal radiator located at the input of the antenna.

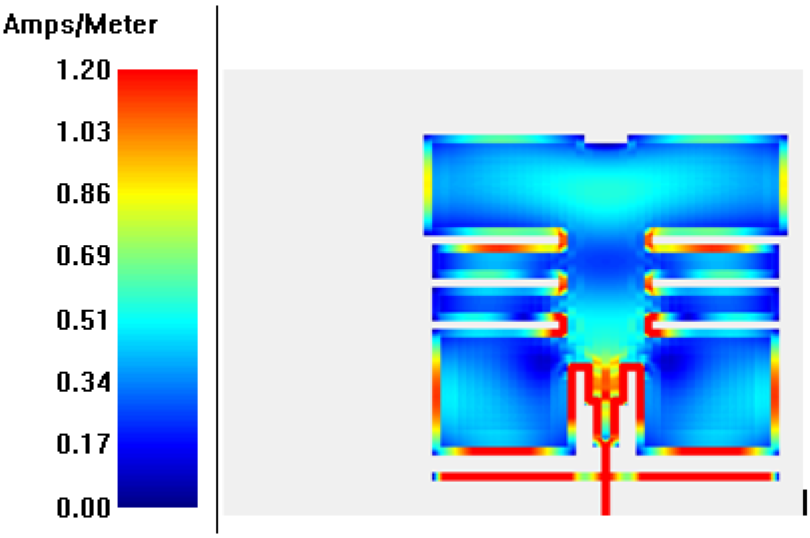

Fig. 5. Current distribution on the antenna at 7.1 GHz.

Finally, in order to get rid of the long edge-feeding line, probe-feeding is applied. Figure 6 has the top view, and Figure 7 has the 3D view of the probe-feeded antenna.

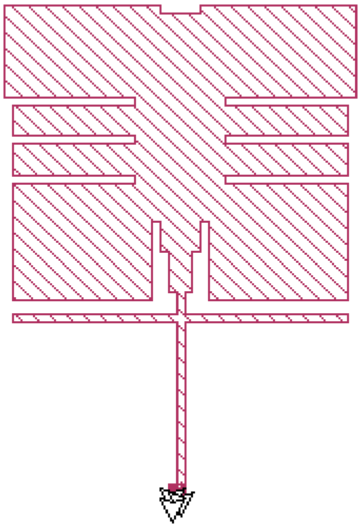

Fig.6. Top view of the probe-fed antenna.

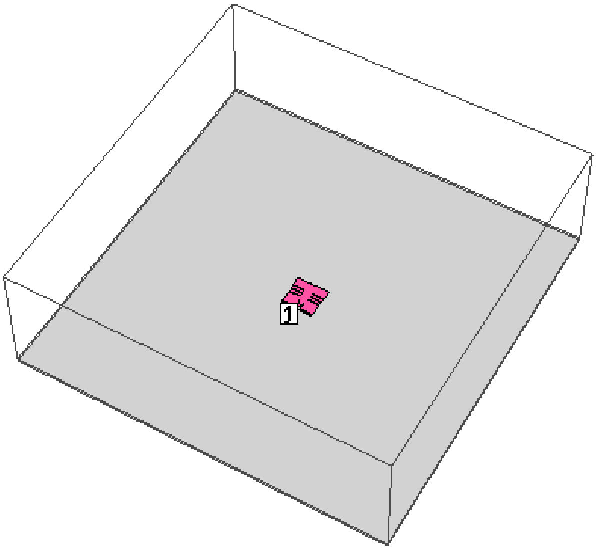

Fig.7. 3D view of the probe-fed antenna.

Figure 8 has the return loss of the antenna at 6.92 GHz and 6.99 GHz. Figure show that, magnitude odf the return loss and the center frequency did not change much as compared to edge-feeding, but bandwidth decreased to 4%.

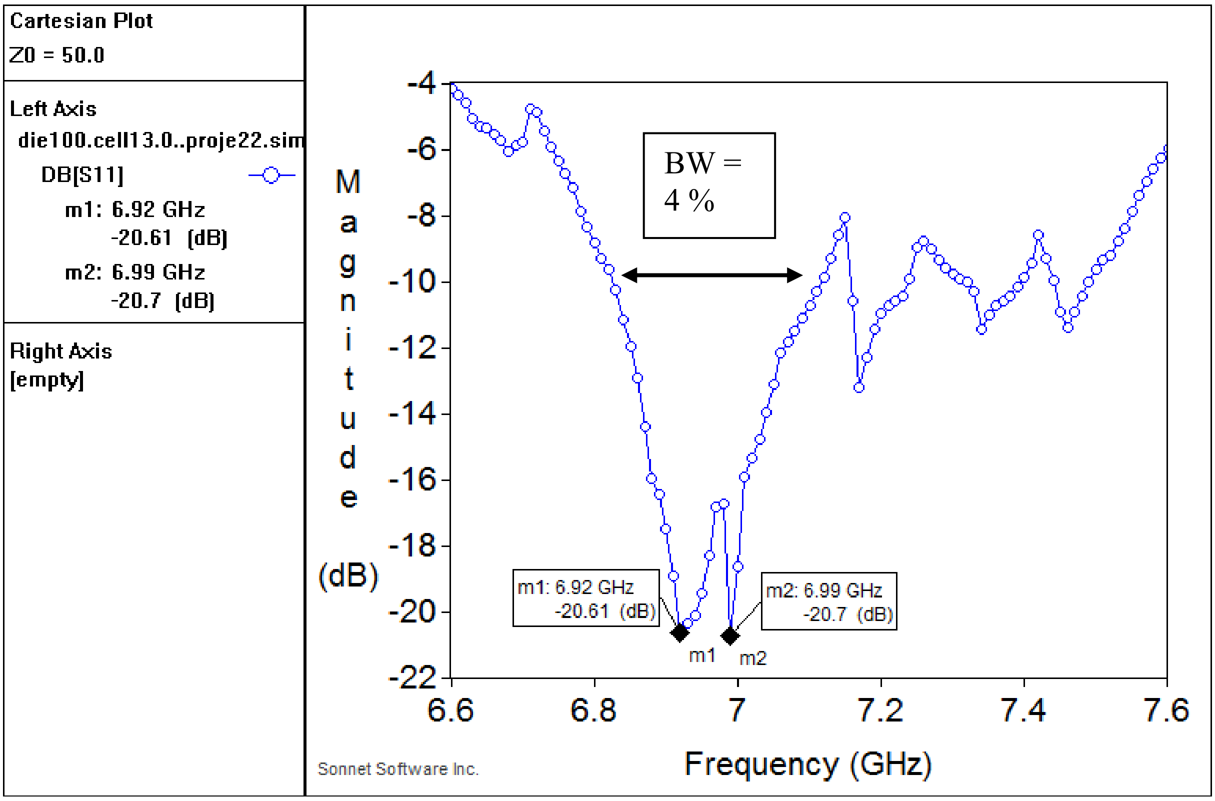

Fig. 8. Return loss of the patch antenna.

Real part of the input impedance is 57.04 Ω, and the imaginary part of the input impedance is –7.1 Ω and maximum gain is 6.83 dB for the 6.92GHz. Radiation pattern is on Figure 9. As it is seen on the figure that, the cross-pol. level (E-theta) is increased to approximately –10 dB, at the endfire radiation directions.

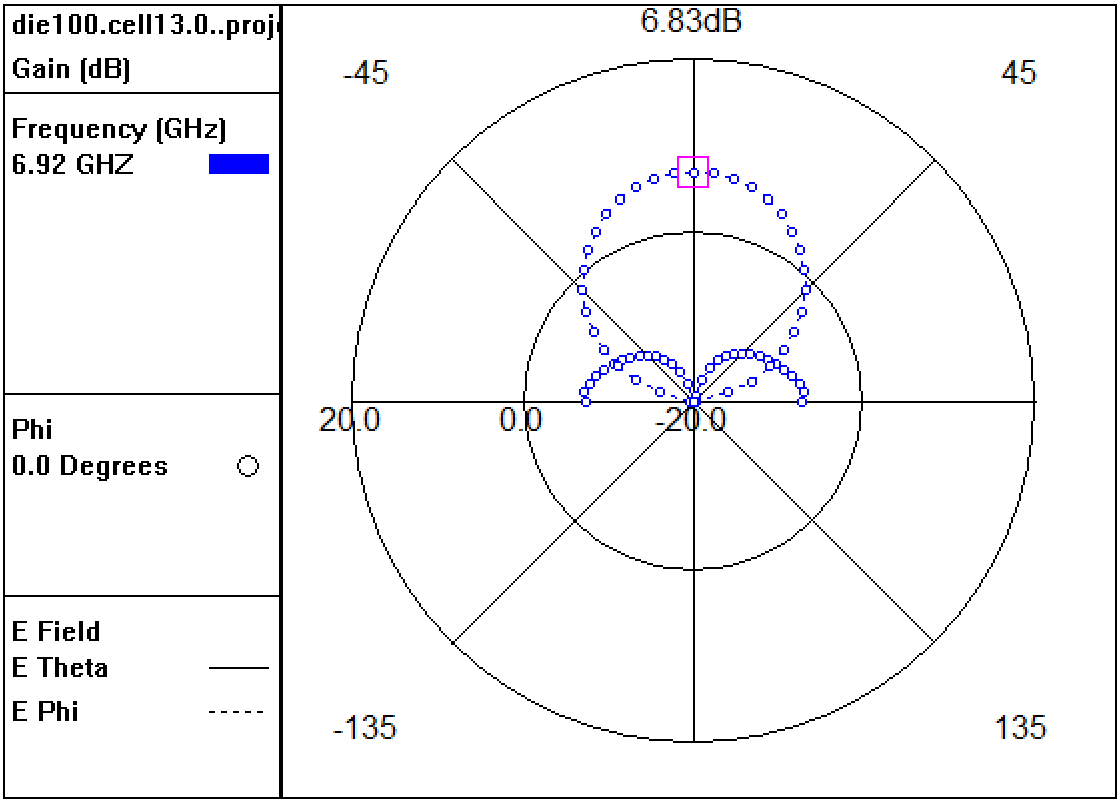

Fig. 9. Far field radiation pattern of the antenna at 6.92 GHz.

4. Conclusions

A microstrip patch antenna at a resonance frequency of 7.03 GHz, with 50.3 Ω input impedance, 10% of bandwidth, and 4.5 dB of phi-polarized gain is achieved. The gain is increased to 6.83 dB when probe-feeding is applied. Design is modified by changing the geometry in order to reach the design specifications. The main design challenge was having low gain in spite of a few resonances of low return losses at different frequencies. For example, there is a resonance at 17 GHz but the gain is at minus digit levels. Further studies might be conducted to improve this. The goal is to have a multiple resonance antenna with wider bandwidths.

References

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